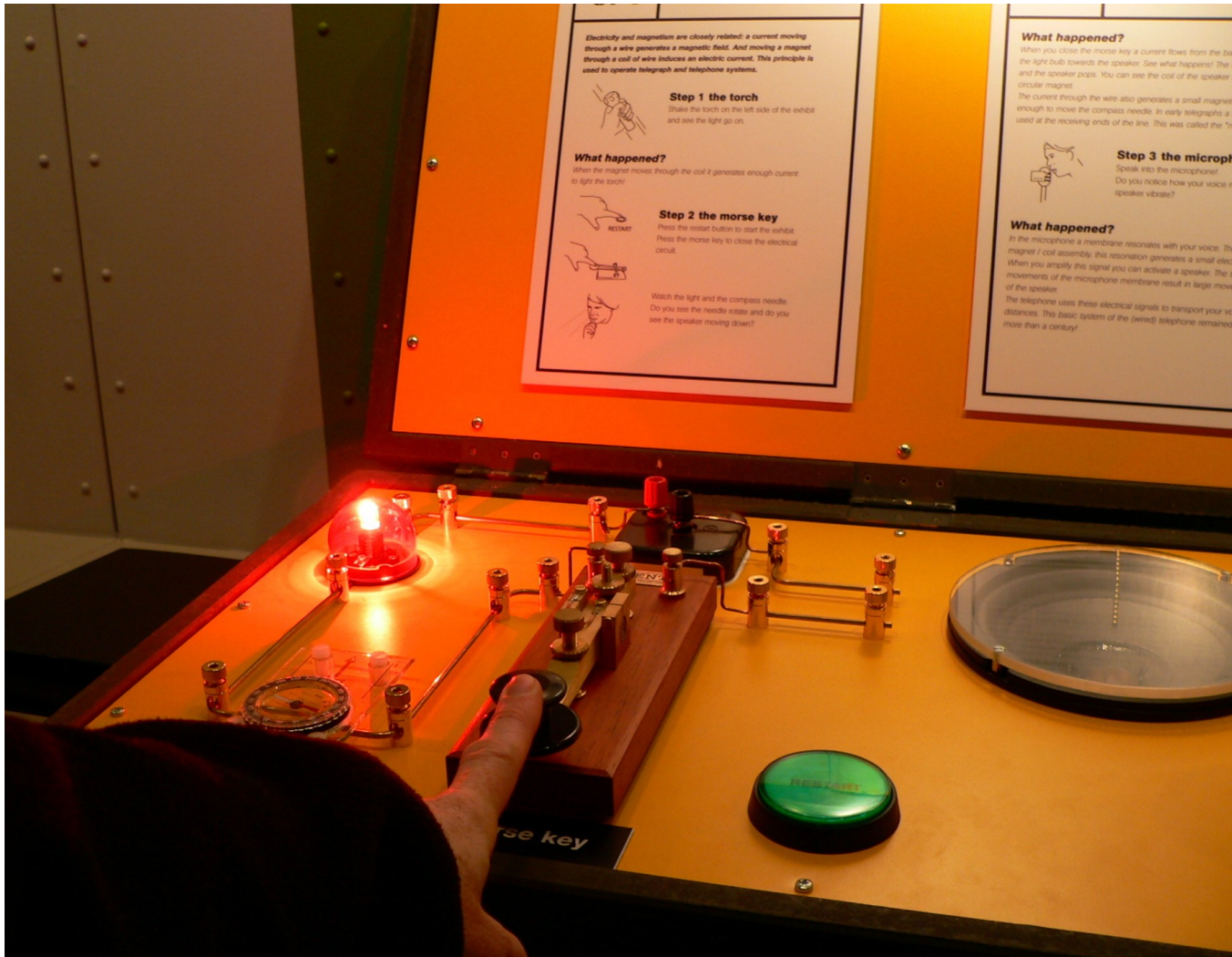
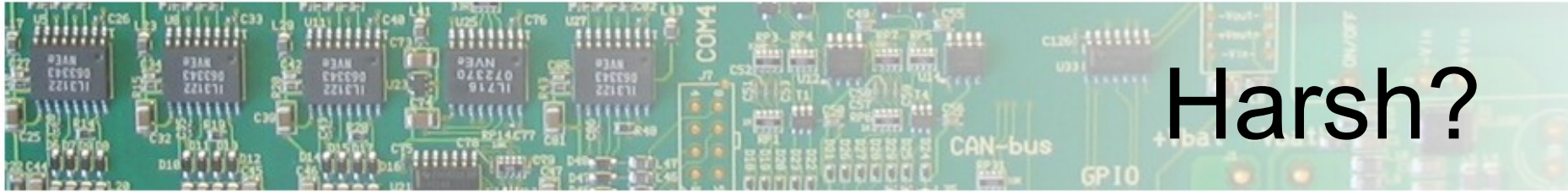
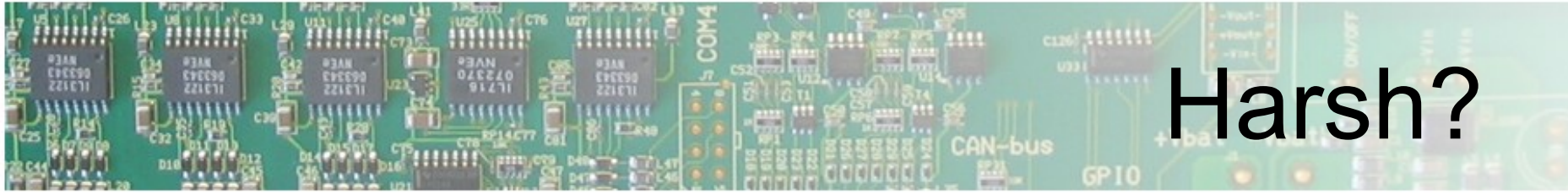
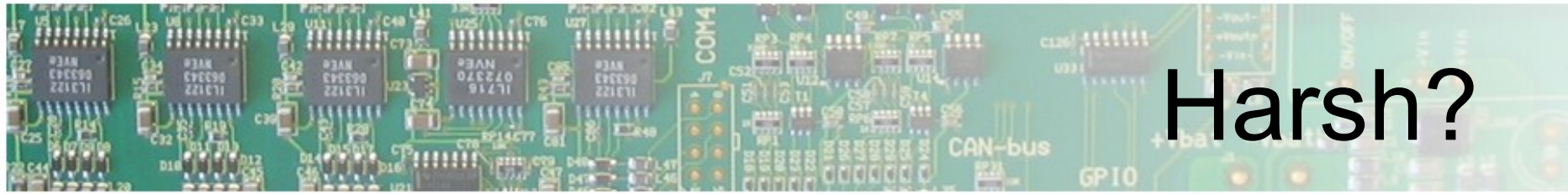


Soft electronics in harsh environments

Andries Lohmeijer
DGA KITT Engineering

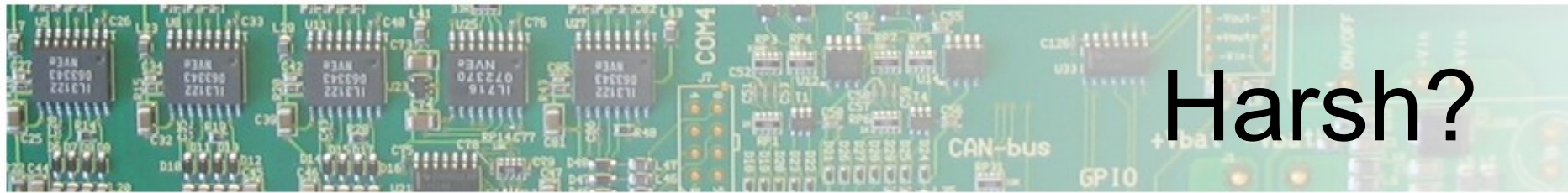


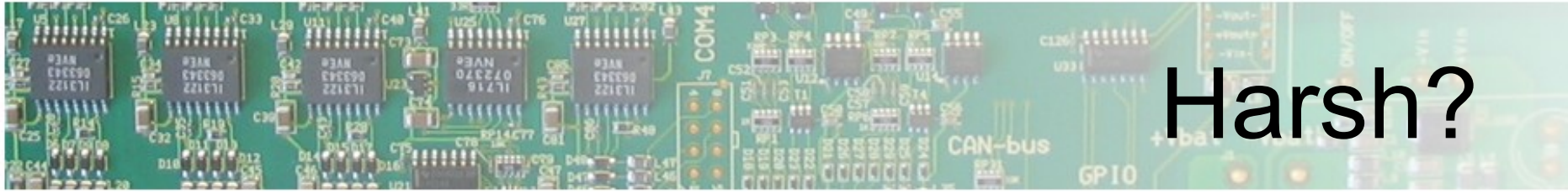




Harsh?

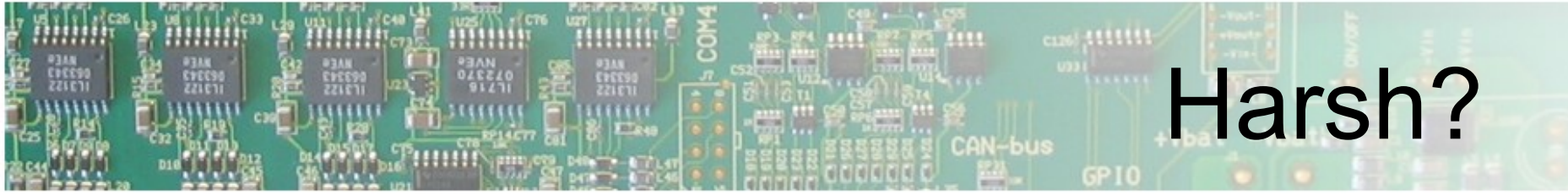


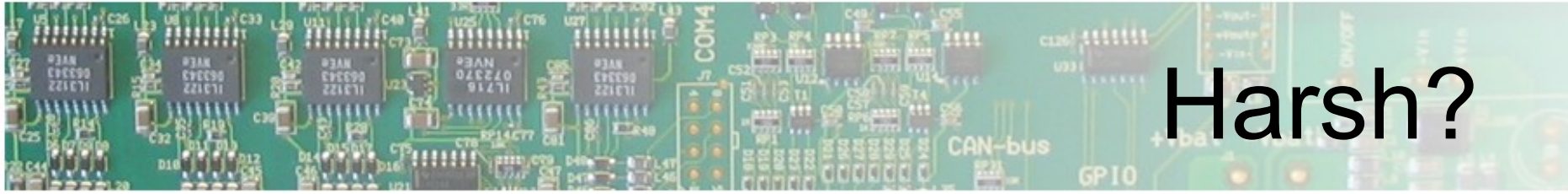




Harsh?

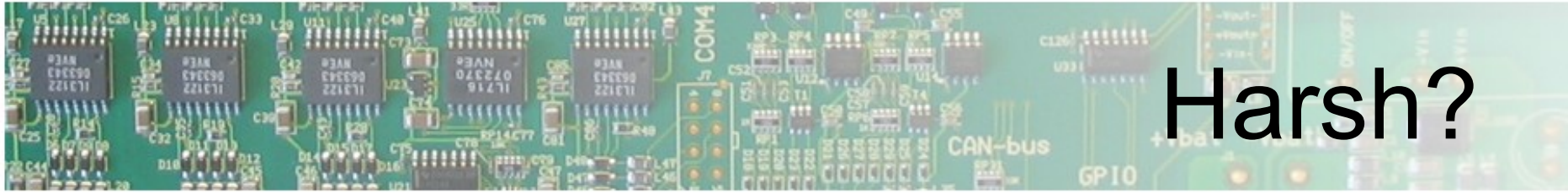




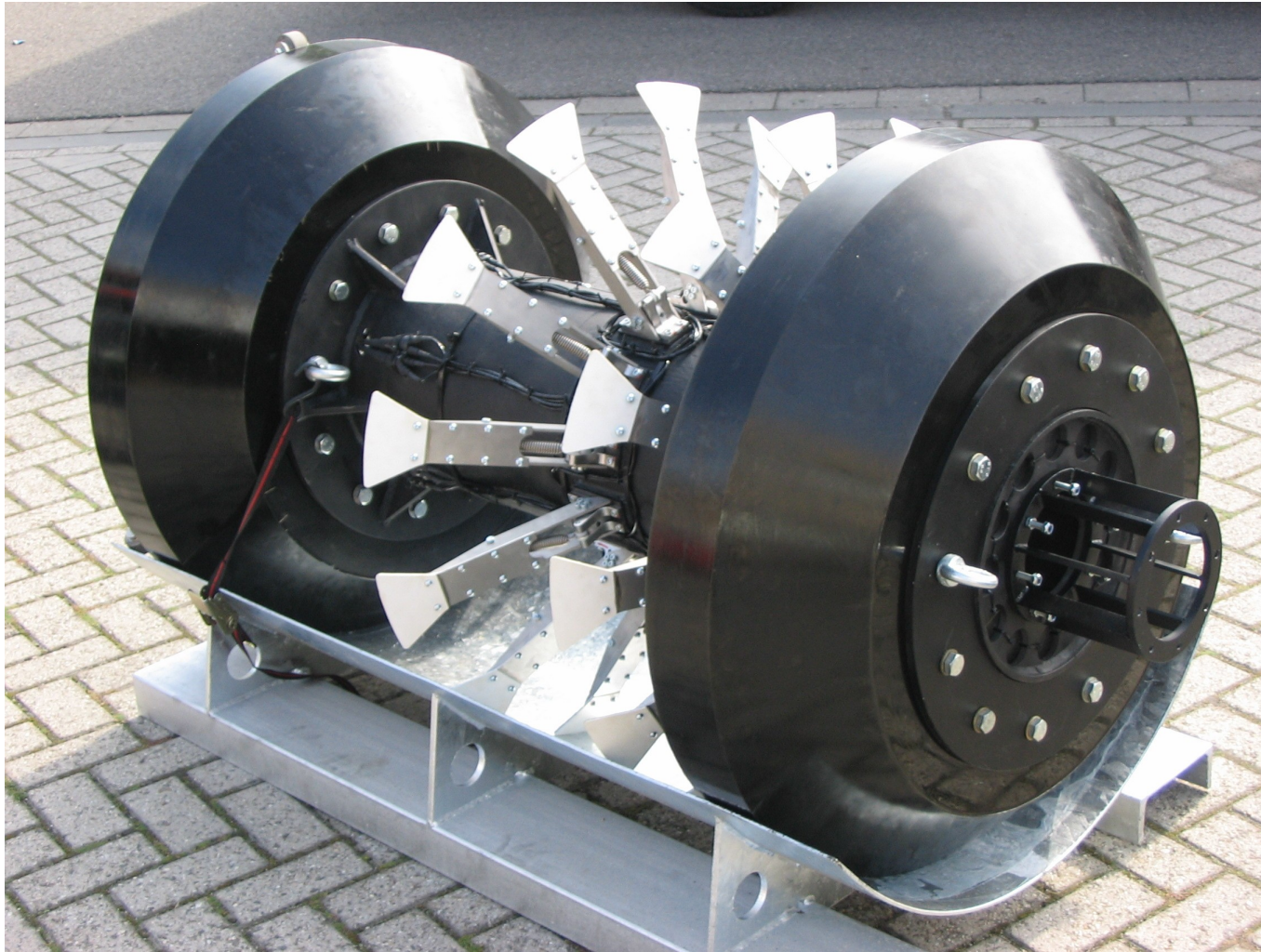


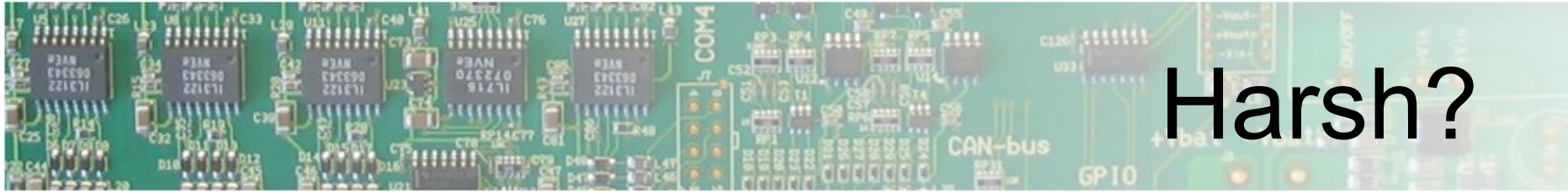
Harsh?





Harsh?

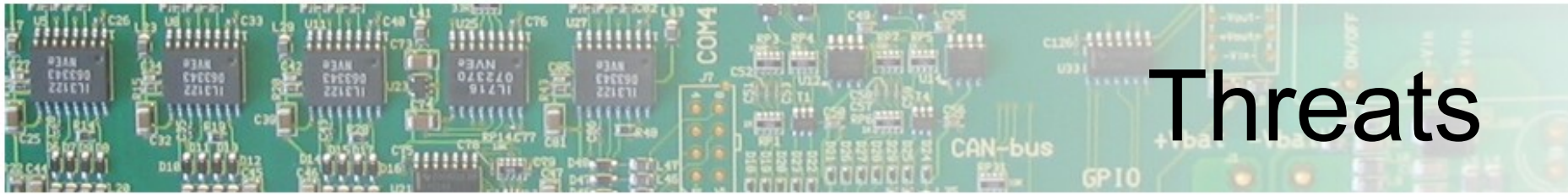




Harsh?

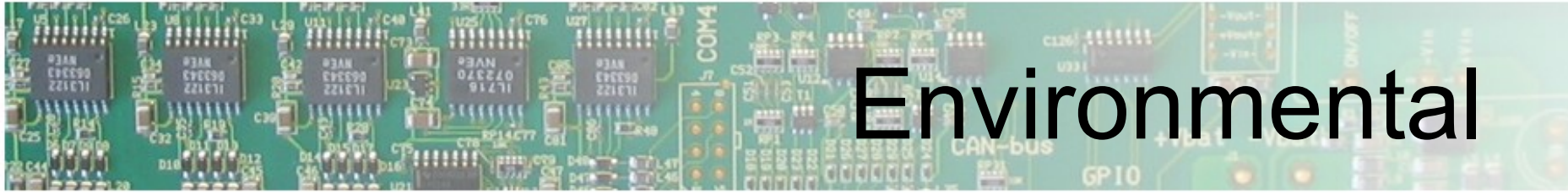
What should we consider to be harsh?

"Conditions that impair normal operation".



Threats

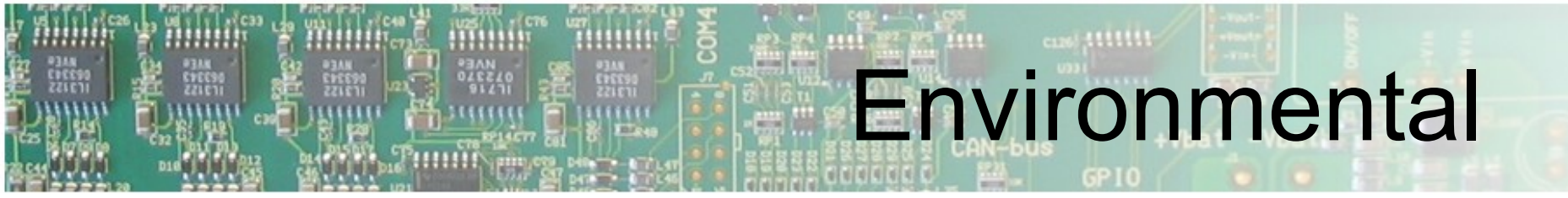
- Temperature
- Water, humidity condensation
- Corrosive, saltwater, acids, smoke
- Solvents, petrol, paint,
- Radiation, Sun, UV, heat, X and Gamma rays
- Electromagnetic fields, GSM phones etc.
- Shocks, vibration
- Static Discharge



Environmental

Temperature

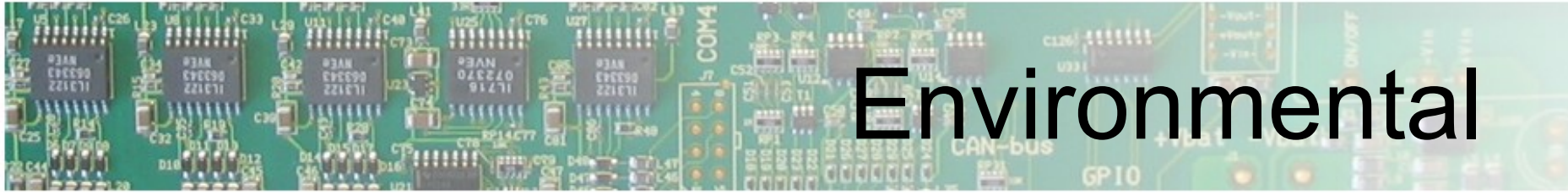
- Commercial 0°C .. 70°C
- Industrial -40°C .. +85°C
- Junction temperature :
Silicium 120°C Organic LED's < 70°C
- Observe internal dissipation + high ambient temperatures!
- Thermal stresses and thermal shocks!!



Environmental

Humidity

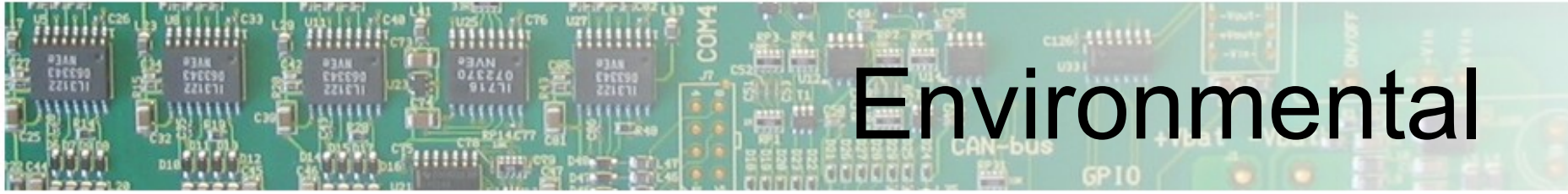
- 20% to 95% RH non condensing
- Surface resistance
- Creep distances 4mm class I, 8 mm class II
- High impedance circuits...
- Temperature Gradients



Environmental

Altitude

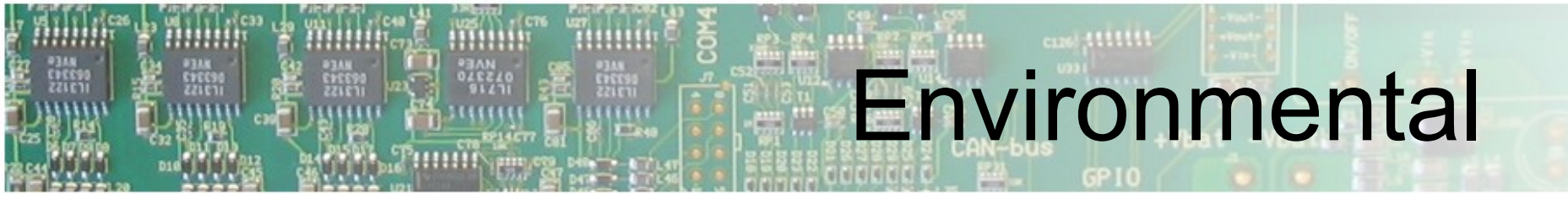
- Normally up to 3 km
- Creep distance increases with lower air density!



Environmental

Pollution

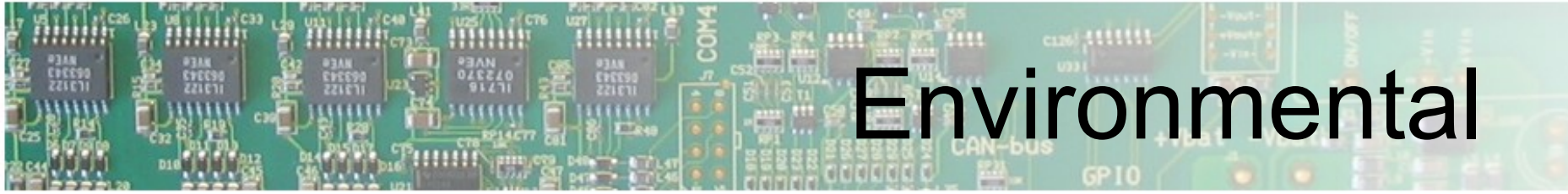
- Pollution attracts moist
- Smoke (carbon) is conductive and corrosive
- Corrosion → Salts → attracts water → more....
- (forced) air convection collects dust etc.
- Dust may block proper ventilation
- Raised ambient ?????



Environmental

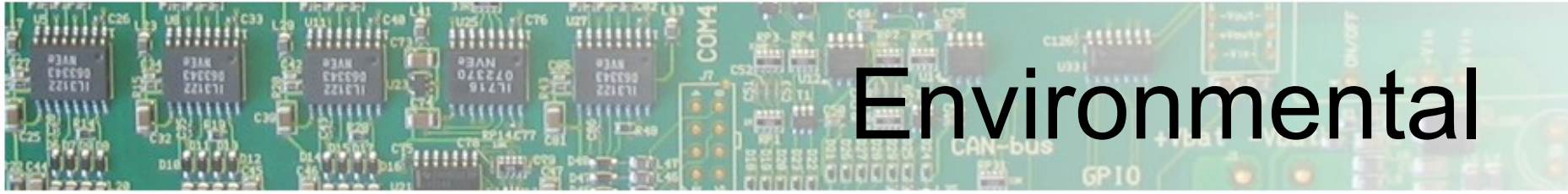
Solvents

- Degrade plastics and insulators
- May cause delamination of PCB's
- Change (di)electrical properties of material
- Fire hazard if ignited
- Time-bomb effects



Radiation

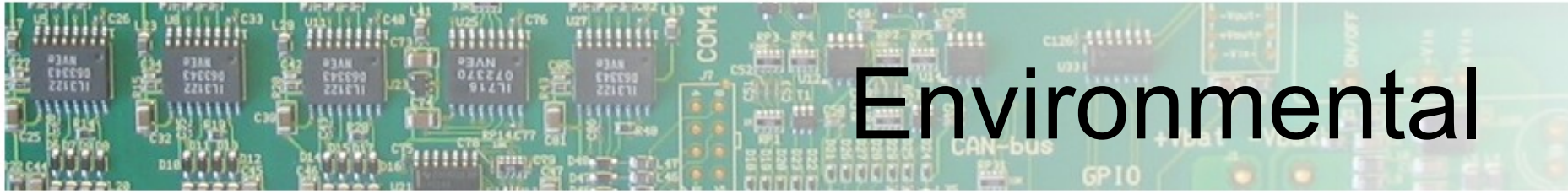
- Sun up to 1200 W/m^2 → Heat
- UV in sunlight destroys plastics
- NIR may blind sensors
- IR heat accumulation
- Gamma Rays and cosmic particles flip bits in all kinds of memory. Free lottery!!



EMC

Electro Magnetic Compatibility

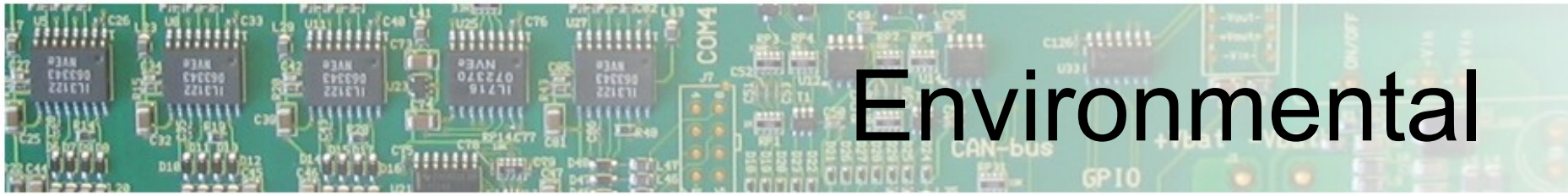
- Radiated Immunity
- Conducted Immunity
- Emitted Radiation
- Conducted Radiation
- Transients
- Surges



ESD

Electro Static Discharge

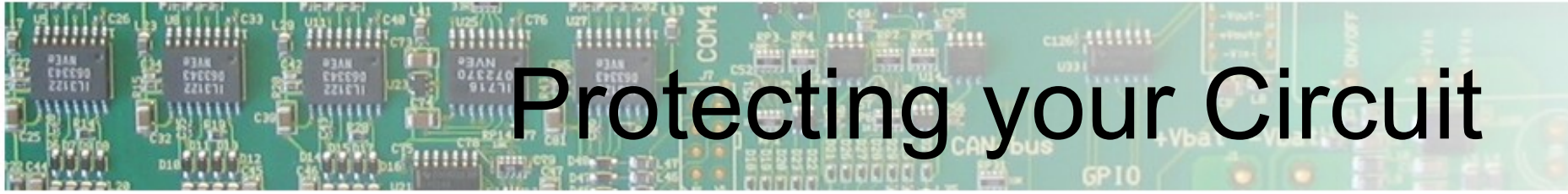
- Contact discharge (human body model)
- Inducted discharge
- Permanent damage, hidden damage
- Causes latchup of CMOS circuits
- Induces spikes and transients into the circuit
- Unpredictable results



Environmental

Shocks and vibration

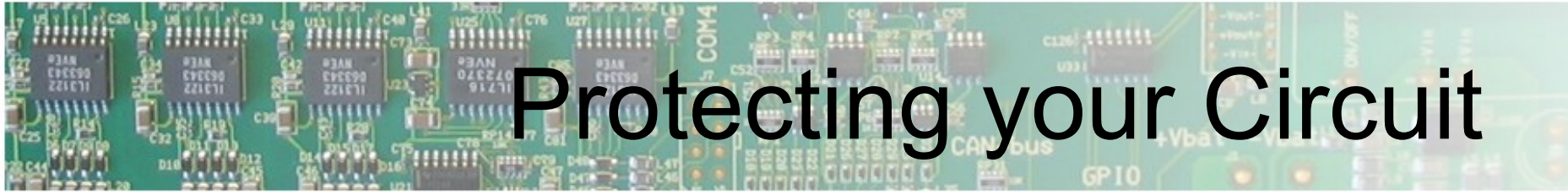
- Material fatigue
- Loosing screws and connections
- Damage to insulation of wires
- Stress on components
- Microphony in the circuit (ceramic C's)
- Hazard: observe single point of failure!!!



Protecting your Circuit

Housing IP class

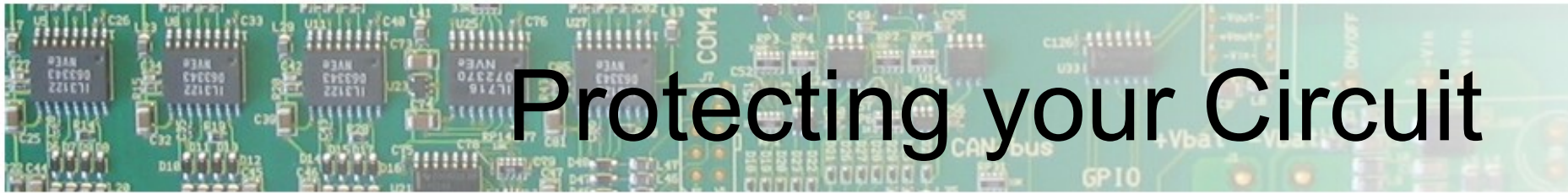
- IP54 : Dust protected , Splashing Water
- IP65 : Dust tight, water jets
- IP67 : Dust tight, immersion 1 meter of water
- Use glands (wartels)
- Use ventholes if needed



Protecting your Circuit

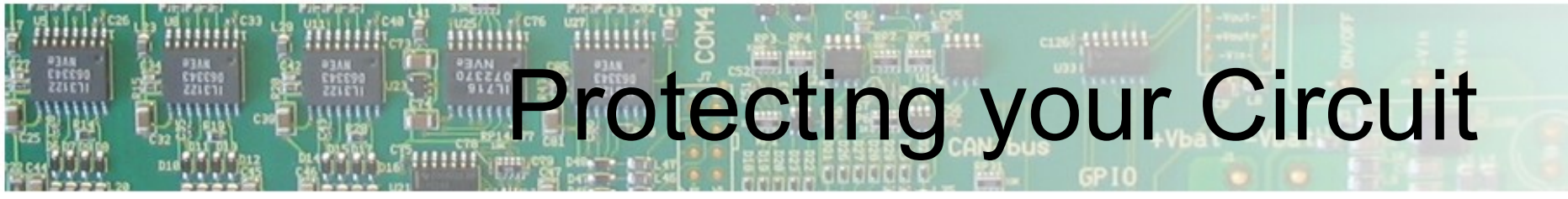
Temperature

- Design heating and cooling to meet worse case conditions
- Observe internal dissipation
- What happens in an overload condition?
- Will your fuse blow?



Protecting your Circuit

- Avoid direct sun exposure
- If exposed check UV resistance
- If exposed observe your thermal management
- Satellites are wrapped in reflecting foils...



Protecting your Circuit

EMC and ESD

- How many open toko's do we need???
- Inventory for the next Toko ??
- Questions and Questions and more....
- Let's have a look at Harmen's "problems"...